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An Anatomical-Functional Review of Selected CNS Motor Control Structures

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NOTE: The following article was written especially for the MONOGRAPH. The Author is Professor of Physical Education, University of Toledo, and was a guest speaker at the 1975 NUCCA convention.

A Model of Motor Control. Human motor behavior, including postural, transport and manipulative activities, represents some of the most complex phenomena known to man. The nature of the neurological processes and/or mechanisms underlying the execution of such behaviors is very complex. Thus the job of describing something about the neurological substrate of human motor behavior is at best a difficult one. Since we can only deal with the complexities of such processes by simplifying or organizing available information into some basic functional and/or conceptual framework, I shall begin our anatomical-functional review of CNS mechanisms of motor control by describing a general schematic model of motor control. The significance of this approach lies in the fact that it is important to know first the broad, general picture of neural control of motor activity and then to begin to attempt to fill in the details about specific mechanisms involved.

The model I have chosen to discuss is that proposed by Bernstein, a Russian neurophysiologist and published by the Pergammon Press in 1967. (See Figure 1) According to this model, control of either reflex or voluntary behavior is initiated by sensory receptors which pick-up the information prerequisite to ordering a motor command. This motor command eventually activates or initiates the overt behavioral response we see as movement. Prior to the actual initiation of the overt response, the information picked-up and analyzed by the system is sent to a 'command center' which then issues a command or executive order to the motor mechanisms of the spinal cord and peripheral musculature. This plan or order which comes from the higher centers of the brain is only a general plan of action. The lower brain centers including the motor mechanisms of the spinal cord add important specifics or details to the movement to be initiated.

Simultaneously with the issuance of the command to these lower brain peripheral centers, a copy of the motor command is also sent to a 'comparator system' (probably the cerebellum). As movement occurs, feedback from the ongoing movement is sent to the 'comparator system' which compares the actual course of movement with the intended plan of action and detects errors in the ongoing movement on the basis of the final intent or goal of the movement. This error message is sent to the 'recoding center' or 'efferent corollary center'. The 'recoding center' codes the error message into an error correction. That is, it asks and answers the question "if the system is making this kind of error in movement now, what action or actions must be taken to correct this error in order to re-establish adequate control or to achieve the intended goal of the movement"?

The error correction message (the answer) is then sent to the 'regulatory center' which sends a message to the appropriate lower brain centers and to the alpha motor neurons of the

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Profiles in Chiropractic

H. L. Stephens D. C.

Editor's Note: The MONOGRAPH's series of profiles of its distinguished members features in this issue Dr. H. L. Stephens, 121 South Creek, Holdenville, Oklahoma. A well-known doctor of chiropractic, Dr. Stephens has practiced for over 26 years.

Many people have chosen chiropractic as a profession because it provided a solution to their own health problem. Unable to find relief in other systems of health, they sought and found help in chiropractic as a last resort. This occurred in the case of the subject of this MONOGRAPH's profile.

"I spent over a year in seven different hospitals", says Dr. Stephens, "and I kept getting worse. I was told eventually that it was all my 'imagination', and finally that 'my pain did not even exist'. I then sought chiropractic because I was desperate and pain-ridden. When Dr. C. N. Gray of Okmulgee, Oklahoma explained to me the cause of my health problem, it made sense. When he adjusted my atlas vertebra and I

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began to recover, I knew that the chiropractic principle was right, and I applied for admission to the Palmer College of Chiropractic in Davenport, Iowa in 1946".

Born in Honeygrove, Texas in 1913, Dr. Stephens was the only boy in a family of four children. After completing his formal education, he enlisted in the U.S. Army. Athletically inclined, a good baseball and basketball player during his school years, he engaged in boxing during his service period. Illness, however, was to change his life.

Returning to Oklahoma after receiving his degree in chiropractic, Dr. Stephens obtained a license to practice in Oklahoma, and started a practice in Okmulgee. Later, he was to move to Holdenville where he has practiced ever since. In 1950 Dr. Stephens started an annual series of post-graduate work in specific upper cervical techniques conducted by Dr. John F. Grostic of Ann Arbor, Michigan, and he has affiliated with upper cervical work since that time. He is now a member of the National Upper Cervical Chiropractic Association. Inc. (NUCCA).

Of NUCCA, Dr. Stephens says: "I am a member of this organization because it is the only organization engaged in researching the atlas subluxation and its effects on the human organism. Chiropractic has the greatest health principle in the world - the subluxation and its reduction - but we need acceptable proof. NUCCA, through its sister organization NUCCRA, is providing that proof by researching the effects of an atlas subluxation on the body, using measurement methods applied to both the subluxation and the effects. NUCCA members are in good hands".

Dr. Stephens is also a member of the International Chiropractors' Association and of the Chiropractic Association of Oklahoma. He is a member of the American Legion and of the Elks.

Asked about his personal philosophy, Dr. Stephens replied: "I believe that destiny - the force power or principle that predetermines events - plays a geat role in shaping our lives. What, in other words, is to be will be. The course of events is inevitable. On the other hand, my philosophy of practice is equally simple: pursue always a straight course by adhering strictly to the subluxation principle. Never let yourself become lost in the maze of complexities. Keep clear of the pitfalls. Stay with the Atlas Subluxation Complex reduction principle and it will bring you through. This is the advice that I would offer to any chiropractor after 26 years of practice."

Speaking of his most unusual case, Dr. Stephens said: "Probably a case of asthma, a five-months old baby boy who weighed only five pounds when his parents first brought him to me. He had been asthmatic since birth and medically diagnosed as having had several attacks of pneumonia in his very short life. The parents had been informed that the boy couldn't live, and I believed the prognosis as I looked at him for the first time. I didn't know whether to accept the case. Desperate, the parents asked what I could do for the boy, and, of course, I could promise nothing except to remove the nerve interference. This I did, and today that baby boy has grown into a man, free of asthma, and with a fine family of his own."

Dr. Stephens' hobbies are fishing, hunting, organic gardening, and baking bread.

The Case of Mrs. Marlyin White

Editor's Note: In two previous issues of the MONOGRAPH, the Editor reported the apparent successful results in the cases of two cancer victims, resulting from manual reductions of the Atlas Subluxation Complex. This issue includes the interesting story of another cancer case: Mrs. Marylin White of Grayslake, Illinois, who noted that, while receiving adjustments from Dr. M. Dickholtz, Chicago, Illinois, for another health problem, her skin cancer did not recurr; neither did any new cancerous leisons appear. Mrs. White tells her story:

In may of 1970, I started having severe pains in my neck, shoulders, and arms. I was unable to lift my arms above my shoulders without great difficulty. Also during this time, I was unable to sleep much at night due to this extreme condition. I had recently moved to a new area and was not acquainted with the medical facilities. However, a neighbor made an appointment for me with a local physician, and after an examination, he informed me I was not getting the proper type of exercise, thus causing my problem. He prescribed some arm and upper body exercises for me to take three times a day. After two days of these exercises, my condition was so much worse that I was physically unable to continue them. The physician then instructed me to

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spinal cord which transmit the message to the peripheral muscles where the desired modification in motor behavior is achieved. Feedback from this correction in movement (via movement-produced feedback) then reenters the system and the whole cycle is repeated: error detection, error correction and movement modification. This continues until either the goal of the movement is achieved or the organism stops moving altogether.

Certain brain structures have been identified which seem to possess some of the functional and anatomical characteristics required to fulfill the prescribed operations of various parts of this model. These are described in Table 1, and it is to some of these structures that I should like briefly to direct your attention.

The Cerebellum. I would like to make a few comments about the cerebellum because of its clearcut and complex involvement in spinal and cortical activity related to control of both voluntary and reflex motor behaviors.

Fundamentals of cerebellar anatomy were established in 1888 by

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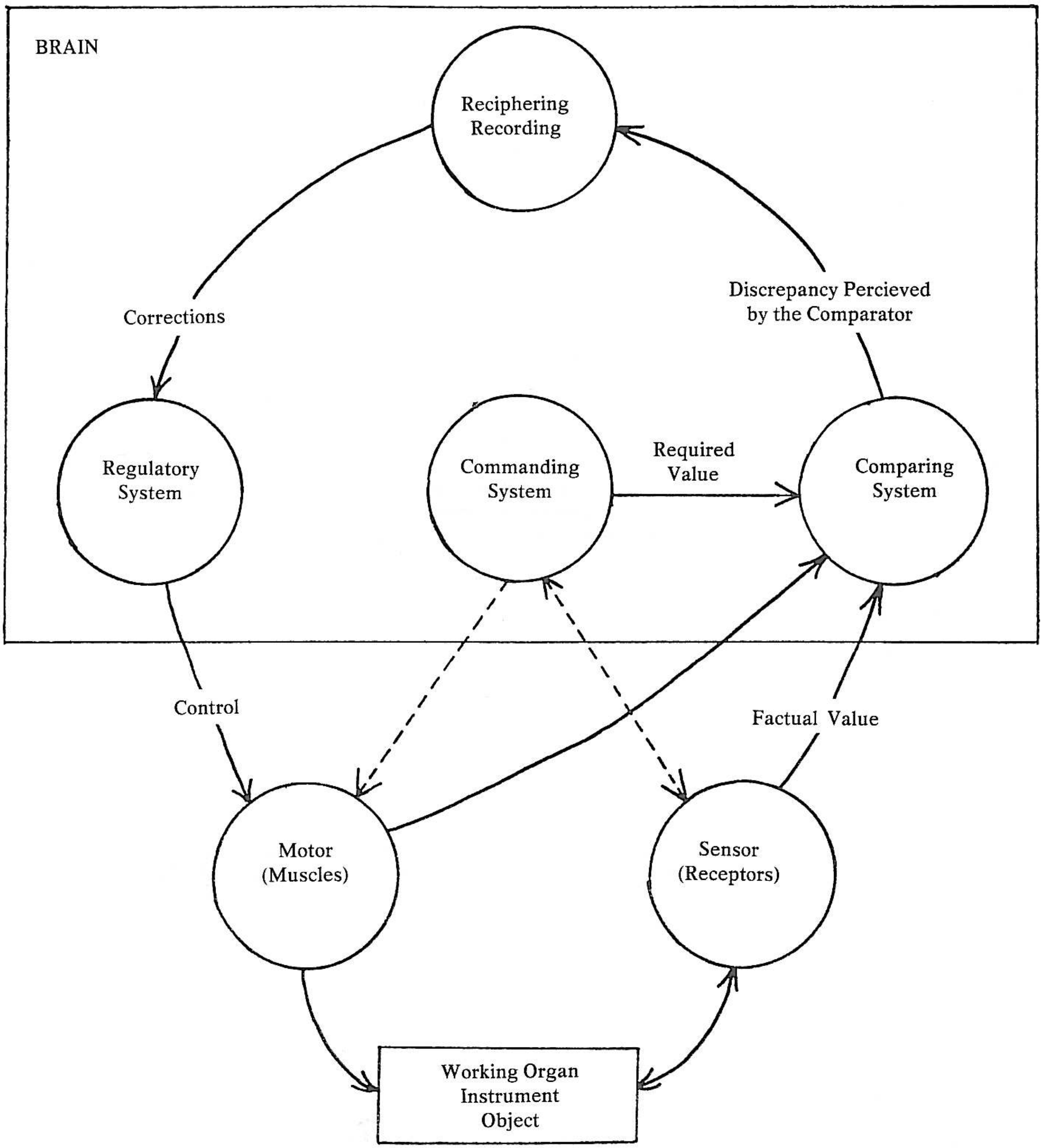
Figure 1. Bernstein Model of Motor Control



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Model Operation	Implicated Brain Structure
Input/Receptor System	Sensory Receptors and Associated Afferent Pathways
Motor Command Center	Motor Cortex, Pre-Motor area, Supplementary Motor Areas of Cerebral Hemispheres; Basal Ganglia
Recoding Center	Cerebellum
Error Correction Center	Cerebellum, Reticular System, Basal Ganglia
Regulatory System	Motor Cortex, Pre-motor area of Cerebral Cortex; Basal Ganglia, Spinal Cord Motor Mechanisms

Table 1. Brain Structures Implicated in the Bernstein Model of Motor Control.

Ramon y Cajal of Spain. Through these early investigative efforts, it was established (1) that animals deprived of a cerebellum or with cerebellar lesions suffered from disturbances of coordination and equilibrium and (2) that important functional neuronal circuits existed between the cerebellum and the motor centers of the cerebrum and the peripheral proprioceptive organs of the body. Thus there seemed (even very early) to be little doubt that the cerebellum was intricately related to CNS mechanisms involved in both voluntary and reflex movements. Let us begin looking at this important motor control center by examining **(a)** some organizational characteristics of the cerebellum itself and **(b)** by reviewing some of the anatomical functional interrelationships between the cerebellum and other important brain structures.

Organizational Characteristics. The cerebellum is organized on much the same basis as a computer. That is, it functions internally in terms of input operations, central data processing operations and output operations. It is composed of seven basic cell types. Two of these cells are input cells which pick-up information from other parts of the nervous system and send it on to the internuncial or central data processing cells of the cerebellum. The CDP cells of the cerebellum are four in number and possess very intricate neurophysiological characteristics. They seem, in general, to act as interpreters or modulators of the input provided to the cerebellum by the mossy and climbing fiber input cells. This modulated information is then sent out from the cerebellum to various parts of the nervous system via the Purkinje or major output cells of the cerebellum.

In addition, each proprioceptive nerve ending in peripheral skeletal muscle projects or corresponds to a particular position on the surface of the cerebellum. When one plots these positions systematically along the surface of the cerebellar cortex through electrical stimulation techniques, one derives a homonculus which represents in a distorted fashion the various muscles of the body. Thus the body's musculature with which the cerebellum is so intricately involved in regulating is clearly represented somatopically in the cerebellar cortex. The cerebellum thus appears to be organized in a highly specific and functionally meaningful manner.

Functional Interrelationships with other Brain Structures. By what means does the cerebellum communicate with other brain structures to coordinate voluntary and reflex motor activities? The first question that one might ask in attempting to answer this question is from where does the cerebellum receive its afferent input? Afferent input is received by the cerebellum from (1) the **corticocerebellar tracts** which originate in the **motor cortex.** By means of these pathways the cerebellum can communicate directly with one of the major command centers for voluntary activity; (2) at least two important **brainstem mechanisms** - the **striate body** (two of the basal ganglia) and the **reticular formation** by way of the **olivocerebellar** and **reticulocerebellar tracts** respectively. These pathways provide for functional interrelationships with the command center for more automatic or well-learned motor acts (the basal ganglia) and a brain structure which has widespread facilitatory and inhibitory connections with many parts of the brain including both higher cortical and lower spinal cord motor control mechanisms (the reticular formation); (3) the **vertibular nuclei** via the **vestibulocerebellar tracts.** This pathway provides important information about the boyd's position in space; and (4) the **muscle spindles and Golgi tendon organs of the peripheral skeletal musculature.** This information which describes the degree of tension or contraction in the muscle itself arrives at the cerebellum via the very fast conducting **spinocerebellar tracts;** (5) other brain structures including the **visual, auditory, and visceral systems.** Input from all of these sources terminates in spatially and somatotopically organized areas in the cerebellar cortex and provides information at a subconscious level about the status of the body, its position and movement through space.

What about efferent output from the cerebellum? There are four efferent output pathways from the cerebellum. These arise in the four cerebellar nuclei, the dentate, globose, emboliform and fastigial nuclei. Three of these (the dentate, globose, emboliform nuclei) project fibers upward to the red nucleus, to the reticular formation and to the thalamus (ventrolateral nucleus) and via the thalamus to the motor cortex. The fastigial nucleus sends fibers to the lower reticular formation and from there to the spinal cord. These efferent connections make it very clear that the cerebellum functions in motor control only in association with activities initiated elsewhere in the CNS. That is, the cerebellum only modulates or reorganizes motor activities; it does not initiate them.

If the cerebellum acts as a coordinator or modulator of motor activity, let us examine in a little more detail just how it accomplishes this feat.

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(1) When efferent impulses are transmitted from the cerebral cortex downward through the corticospinal tract to motor neurons of the spinal cord, collateral impulses are transmitted simultaneously to the cerebellum.

(2) When movement occurs, information from the peripheral receptors about the movement is transmitted via the spinocerebellar tracts back to the cerebellum. These impulses go to the same parts of the anterior cerebellum that are stimulated by the original descending impulses from the motor cortex.

(3) These two sets of signals are then integrated in the cerebellum, and efferent impulses describing errors in the two sets of signals are transmitted upward to the motor cortex, via brainstem mechanisms, to where the motor command first originated. Corrections are then made in the ongoing motor act via modulation of motor cortex/basal ganglia activity. This series of events is of course very similar to those described in the Bernstein model.

The cerebellum functions essentially to assess the rate at which movement is occurring and to calculate the length of time that will be required to reach the point of intention. Because the motor cortex operates on the principle of sending out more impulses than are needed to accomplish a given motor act, the cerebellum must send out appropriate inhibitory impulses to the motor cortex. The cortical centers then send out messages to the lower centers to apply the appropriate 'brakes', so to speak, to stop the movement at the precise point of intention. The spinal cord mechanisms are largely responsible for executing this 'braking' action.

Feedback from the periphery via spinal cord mechanisms is vital to this whole process of error detection and error correction for without appropriate feedback, the cerebellum could not perform its comparator functions properly. When there is no feedback or if there is a cerebellar dysfunction, a person tends to 'lose' his limbs when he moves them rapidly and suffers from the 'failure of progression' phenomenon. This means that he cannot judge or control how far or when to move and thus cannot put together a sequence of coordinated movements (dysmetria). The cerebellum therefore is a brain structure vitally linked to motor control.

The Reticular Formation. Another mechanism that is believed to be involved in error detection/error correction operations is the reticular formation. The brainstem is a complex extension of the spinal cord. Collected in it are numerous neuronal circuits designed to control respiration, cardiovascular function, gastrointestinal function, eye movement, equilibrium, support of the body against gravity and many special stereotyped movements of the body. Throughout the brainstem, which includes the medulla, pons, mesencephalon and part of the diencephalon, are areas composed of diffuse neurons. These aggregations of neurons are known as the reticular formation. The reticular formation begins at the upper end of the spinal cord and extends into the hypothalamus and to the sides of the thalamus. The lower end of the reticular formation is continuous with the internuncial cells of the spinal cord and functions in many respects very similarly to the internuncial system of the spinal cord. The reticular formation is a polysynaptic system made up of several specific nuclei and multiple nerve tracts.

In the reticular formation are many small special nuclei, some of which are third order sensory neurons and some of which are second order motor neurons. All nuclei have some somatotopical organization. These nuclei thought to influence and/or to be responsible for many reflex/subscious motor activities. The reticular formation has both excitatory and inhibitory regions. The pons, mesencephalic and diencephalic projections are excitatory (RAS). The lateral portions of the medullary reticular formation are also excitatory. Only the ventro-medial portion of the medullary reticular formation is inhibitory.

The reticular formation is intrinsically excitable. So that if not inhibited by other parts of the nervous system (basal ganglia and cerebral cortex) it tends to transmit continuous nerve impulses to other brain centers. For example, in decerebrate rigidity, what has happened is that one has removed the inhibitory powers of the basal ganglia and cerebral cortex on the reticular formation so that its excitatory influences predominate and the result is muscular rigidity on the part of the animal, a condition characteristic of the decerebrate preparation. If, however, such transection is made below the level of the vestibular nucleus, all or at least most of the excitatory influence of the reticular formation is lost and its inhibitory influences now dominate. The result in this case is that the peripheral musculature becomes flaccid. There is great loss of muscle tone.

Functions of the reticular formation. A very important function of the reticular formation is that of providing a basis for support of the body against gravity. When a person is in a standing position, continual impulses are transmitted from the reticular formation via the spinal cord to the extensor muscles of the limbs. Contraction of these extensor muscle groups allows for repositioning of the limbs to support the body against the pull of gravity. The normal excitatory nature of the upper reticular formation provides much of the intrinsic excitation required to maintain muscle tone in these antigravity muscles. The precise degree of activity in these muscle groups is determined by the state of equilibrium of the body. Thus if the organism begins to fall to one side, more impulses are sent to the extensor muscles on that side of the body in order to prevent falling, and information sent to the opposite side is reduced producing relaxation and thus the regaining of postural control. This important reticulospinal pathway is, you will see, a part of the extrapyramidal motor system.

The reticular formation is able to function in this way because it receives information about the posi-

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tion of the head with respect to the body and about the rest of the body parts with respect to each other. This information comes from the proprioceptors of the neck and body either directly to the reticular formation or via input provided by the cerebellum. In this instance input from the vestibular mechanism is also important. By far however, the most important proprioceptive information needed for maintenance of equilibrium is that derived from the joint receptors of the neck, information which tells the CNS about the position of the head with respect to the body. This information can oppose and cancel out information from the vestibular apparatus.

The reticular formation may also play an important function in certain stereotyped body movements. Most movements of the trunk and head can be classified into forward flexion, extension, rotation and turning movements of the entire body. These movements are known to be controlled by nuclei contained within the reticular substance of the mesencephalon.

In general, stimulation of the medullary portion of the reticular formation produces inhibition of patellar tendon, flexion and blink reflexes. Thus it acts in a downward way to inhibit activity of spinal motor mechanisms. Stimulation of this area can also produce inhibition of responses caused by stimulation of the motor cortex. Thus the reticular formation can act upward to affect activity in the higher motor centers of the brain. Most regions of the reticular formation, however, cause facilitation of reflexes organized at lower levels of the spinal cord or of cortically induced movement in response to electrical stimulation. The action on spinal cord activity is thought to be effected via direct effects on muscle spindle activity.

The Pyramidal or Corticospinal Motor System. There are two major effector or motor systems by which the CNS controls or regulates posture and/or voluntary motor control. These two systems are the pyramidal or corticospinal system and the extrapyramidal or extracorticospinal system with its related brain structures. The **pyramidal system** is primarily concerned with the regulation of voluntary motor control of a precise or highly complex nature. Motor control generally associated with complexly organized manipulative skills or highly skilled athletic performances. The **extrapyramidal system** is primarily concerned with more basic gross motor control activities that are related to attaining and maintaining posture. Although often discussed independently, the pyramidal and extrapyramidal systems do not function independently of each other for the smooth execution of pyramidal movements implies a refined and concomitant regulation and modulation of postural mechanisms.

The corticospinal system consists of all fibers which originate from cells within the cerebral cortex and which pass through the medullary pyramids, decussate there and enter the spinal cord to terminate in large part upon the central or interneurons of the spinal cord. It is estimated that only 5% of the fibers of the corticospinal system synapse directly on alpha motor neuron cells. This system constitutes the largest and most important descending fiber system in the human neuraxis. It contains well over a million fibers.

The Site or Origin. All of the fibers in the pyramidal tract originate in cortical regions. 30% originate from area 4, the motor cortex area; 20% from the premotor area, area 6, and 25% from cells making upon the somatosensory regions of the cortex. The exact origin of the other 15% is not known but some are thought to arise from areas in both the temporal and occipital lobes.

These fiber pathways pass downward through the internal capsule, through the brainstem and come to the 'surface' in the medullary region as the pyramids. Although this is where decussation occurs, not all fibers decussate and as a result three rather distinct branches of the pyramidal system can be identified within the spinal cord.

1. The largest of these pathways is the lateral or crossed corticospinal tract. This tract consists of 75-90% (varies with individuals) of the descending fibers and is responsible for control of movements on the contralateral side of the body.
2. The second pathway is an uncrossed tract which descends in the anterior portions of the spinal cord and is known as the ventral corticospinal tract. This pathway contributes some to control of movements on the ipsilateral side of the body. The anterior uncrossed tract extends only to the cervical and upper thoracic cord and innervates primarily the muscles of the upper extremities and neck. This tract is found only in man and higher apes. Great variations in the size of this tract have been noted in different individuals.
3. The third tract is a very small uncrossed lateral projection of the original corticospinal tract and helps to account, in part, for the cortical bilateral control of movements in the head, neck and upper extremities.
4. The pyramidal tracts also contain a small proportion of fibers other than those just mentioned. These descend, it is believed, directly from somatosensory areas of the cortex and provide a means by which cortical activity can facilitate or inhibit transmission of data according to input from proprioceptive sensory mechanisms. In all tracts there is considerable intermingling of fibers that influence the musculature of different parts of the body.

55%of all pyramidal tract fibers end in the cervical regions of the spinal cord. Twenty percent (20%) terminate in the thoracic area and 25% extend to the lumbo-sacral areas of the spinal cord. This kind of arrangement would suggest that pyramidal control of the upper extremities is quite significant and has more possibilities than that of the lower regions of the body. This arrangement would also suggest that in the development of the organism there is a significant need for rapid and specific communication between corticospinal activity and those parts of the body that are controlled by the cervical regions of the spinal cord. In terms of sheer physical bulk, this tract deposits its load, so to speak, in a very small area physically, in the cervical regions of the spinal cord. This of course has important implications for possible effects of deviations on bony structures in this region of the spinal cord on pyramidal tract activity.

What is the basic function of the pyramidal tract? The pyramidal tract conveys impulses to the preiphery via the spinal cord mechanisms. These impulses result in volitional movements of modification of volitional movements. This innervation of course forms the basis for the development and control of highly precisioned and complexly organized manual and bodily skills. Any interference with activity/transmission of impluses in this pathway produces loss of voluntary movement that is most marked in the distal parts of the extremities. Proximal joints and gross movements are less severely affected and rarely are permanently affected. Trauma to the corticospinal system also produces a loss of tone in the affected muscles. After a period of time, however, these muscles become more resistant to passive movement and spasticity sets in. Deep tendon reflexes are increased in force and magnitude while superficial reflexes are usually diminished. These latter effects are thought to be due to the destruction of the smaller fibers of the pyramidal system which arise outside the major motor are in the cortex. Although these fibers are a part of the corticospinal tract, they originate from cortical areas which also give rise to extrapyramidal fibers and thus may assume some functions ordinarily attributed to the extrapyramidal system. See Table 2 for a brief description of upper and lower motor neuron lesions.

Upper Motor Neuron Lesions

1. loss of voluntary movement
2. spasticity
3. increased deep tendon reflexes
4. loss of superficial reflexes
5. Babinski Sign

Lower Motor Neuron Lesions

1. loss of all movement, reflex and voluntary
2. loss of tone; flaccid paralysis
3. rapdi atrophy of affected muscles
4. absence of stretch reflex

Table 2. Characteristics of Upper and Lower Motor Neuron Lesions.

The Extrapyramidal System. Let us now consider the extrapyramidal system, the phylogenetically older of the two motor control or regulatory systems. Neurologists have found it difficult to define the extrapyramidal system but have tended to group together the basal ganglia, certain other related brainstem nuclei - particularly the red nucleus and the reticular nuclei -, the cerebellum and its multiple efferent projections as the extrapyramidal system. In the broadest sense, the **extrapyramidal system consists of all of the descending motor tracts that are not included as a part of the corticospinal system.**

This system is considered to provide the neural substrate for important somatic motor functions involved in postural adjustments and in gross movement patterns which are largely reflex in nature. Extrapyramidal system pathways are all multisnyaptic pathways and their projections to and interconnections with other brain structures are very complex and are at the present far from being completely known or understood. There are two basic components or parts of the extrapyramidal system: (1) the cortical component which involves the circuits to and from the cerebral and motor cortices via certain subcortical nuclei and (2) the extrapyramidal system pathways which project to the lower motor neurons of the spinal cord.

The Cortical Component. There are four major nonpyramidal circuits involving the cerebral cortex. Only two of these are important for this discussion.

The corticoreticular projections or circuits. Fibers forming this circuit project directly from frontal and parietal areas of the cerebral cortex to the nuclei of the reticular substance in the medulla and pons regions of the brainstem. These fibers arise from all parts of the cerebral cortex but the largest number originate from the motor and pre-motor areas of the cerebral hemispheres. The return portion of the circuit involves projections to the striate nucleus of the basal ganglia and/or projections to certain thalamic nuclei. These structures then project to the frontal motor areas of the cerebral cortex, completing the circuit. This pathway is believed to exert both facilitatory and inhibitory influences on cortical motor activity.

The corticonuclear projections. The second major cortical component of the extrapyramidal system are the pathways labeled as the cortico-nuclear circuits. These circuits involve complex interconnections between various areas of the cerebral cortex (primarily the anterior half) and the basal ganglia. These pathways are important ones for they tend ultimately to exert inhibitory influences on lower spinal cord motor centers. Descending pathways originating in the basal ganglia exert most of their influence on inter-neurons in the gray matter of the cervical and thoracic areas of the spinal cord. This thus provides an important pathway for communication between higher regions of the brain and the upper regions of the spinal cord. This cortical extra-pyramidal system pathway may also be the site of the initiation of well-learned, highly automatic voluntary behaviors.

In general the cortical components of the extrapyramidal system function as follows. The reticular substance and/or basal ganglia receive data from the cerebral cortex as well as from other sources; fibers from these areas then project to the ventral

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anterior and/or ventral lateral nuclei of the thalamus, which in turn sends fibers to the motor and premotor cortices. The completion of such a neuronal feedback circuit provides a means by which subcortical nuclei of the extrapyramidal system can influence both pyramidal and extra-pyramidal system activity since a large proportion of fibers from both tracts originate from the frontal motor areas of the cerebral cortex.

Extrapyramidal System Pathways to Lower Motor Neurons. There are four major extrapyramidal system pathways to lower motor neurons of the spinal cord. These fiber tracts make-up the reticulospinal, rubro-spinal, bestibulospinal and tecto-spinal pathways.

The reticulospinal tract. Cortical projections to the reticular nuclei give rise in large part to the reticulospinal tracts. These tracts originate from the medial ⅔ of the medullary and pontine reticular substance and descend the entire length of the spinal cord. They ultimately terminate on the internuncial neurons of the spinal cord and affect motor control by interneuronal spinal cord mechanisms. Impulses carried in these pathways are generally thought to be **facilitatory to extensor motor neurons.** This facilitatory effect on extensor motor neuronal activity may be accomplished through direct effects on alpha motor neuronal activity or through effects of extra-pyramidal system activity upon gamma motor neuron functions. It should be noted that the internuncial neurons of the spinal cord which receive impulses via this tract also receive impulses from the pyramidal tract and from descending autonomic nervous system fibers as well. Thus information from a variety of sources impinge upon the same internuncial neurons within the spinal cord allowing for a complex integration of information from all levels and from all parts of the system to determine final regulation of efferent output.

The rubrospinal tract. The fibers of the rubrospinal tract descend from the red nucleus to the spinal cord and terminate in cervical and mid-thoracic levels. These pathways are particularly concerned with the regulation of activity associated with the head, neck and upper extremities of the body. The rubrospinal tract is a pathway through which the cerebral cortex, basal ganglia, cerebellum and substantia nigra can all bring their influence to bear on lower motor neuron activity. Micoelectrode studies have demonstrated that stimulation of cells in the red nucleus produces **facilitation of flexor alpha motor neurons** and inhibition of extensor alpha motor neurons. However, the most important function of the rubrospinal tract seems to be the **control of muscle tone in flexor muscle groups in the head and neck regions.**

The tectospinal tract. Fibers from the tectospinal tract arise mainly in the superior colliculus and in occipital areas of the cerebral cortex. Fibers making up this pathway seem also to project primarily to the cervical region of the spinal cord and synapse only on internuncial neurons there. The significance of the pathway is not clearly understood at present but information carried in these pathways is believed to be involved in regulation of the reflex turning of the head and movements of the arms in response to visual, auditory and/or cutaneous stimuli. This pathway is also believed to be one of the major pathways for automatic scanning movements of the eyes and the head.

The vestibulospinal tract. Fibers in this tract come mainly from the vestibular nerve and the archi-cerebellum. All of the fibers in this tract appear to terminate in the ventral gray region of the cervical spinal cord. Information carried in this tract is believed to have a facilitatory influence on reflex activity of the spinal cord and upon spinal mechanisms which control muscle tone. The influence of this pathway is best shown in decerebrate animals who show extreme rigidity in muscle tone. Lesions of the lateral vestibular nucleus greatly reduce this muscular rigidity in animal preparations. This tract seems also to be involved with the maintenance of balance and the coordination of head and eye movements.

What happens with disturbances of the Extrapyramidal System? Clinically two basic disturbances are associated with extrapyramidal system disease: (1) various types of abnormal involuntary movements - **The Dyskinesias** - including tremor, athetosis, chorea, and ballismus. Of particular interest is the fact that athetoid movements caused from extrapyramidal system impairment and which involve the axial musculature often produce severe torsion of the neck, shoulder girdle and pelvic girdle (torsion spasm); (2) disturbances of muscle tone - these disturbances usually involve increased muscular rigidity and are often the result of or associated with lesions in the basal ganglia.

In conclusion, suffice it to say that even though a lot is known about the neural control of human movement, clear understanding of such processes is still far from complete.

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The Anatometer: Its Use in Practice

by Lloyd C. Pond, D.C.

Having had the privilege of introducing the ANATOMETER to a segment of the chiropractic profession in Albuquerque during the 1976 New Mexico Chiropractic Convention, I feel that I have some insight into its impact upon the minds of the many doctors of chiropractic from different schools of thought and technique to whom I explained the instrument and upon whom I made ANATOMETER measurements. Their reactions were most favorable.

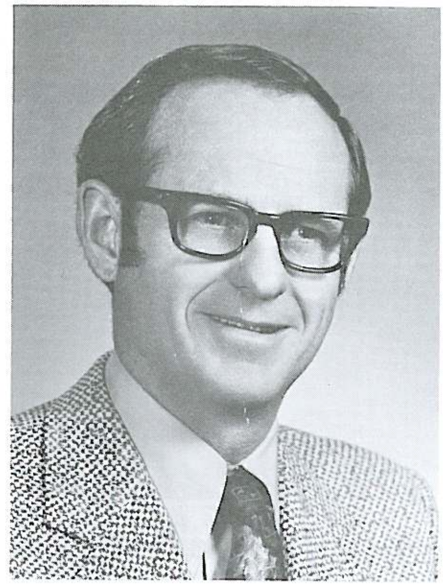
The ANATOMETER's procedures of measurement left no doubt in the doctor's mind concerning the fact that a maximum correction of the vertebral subluxation must be achieved in all its orientation planes if total correction of neurological and muscular balance were to result from a C-1 adjustment, and if maximum results for the patient were to be obtained. In my opinion, maximum correction of the subluxation is the basis of our professional commitment to our patients, our profession, and ourselves. The competence of the chiropractor to demonstrate consistently in measurable terms the beneficial result of his services to the patient is the strongest reason for the acceptance of chiropractic by the scientific community.

The National Upper Cervical Chiropractic Research Association, Inc. (NUCCRA) has for the past five years compiled considerable data relating to the several functions of the ANATOMETER and its ability to measure changes in the physical manifestations of C-1 subluxations before and after adjustment. Much of this data has been published and presented in NUCCA seminars and conventions. This information has now become a reality to me and to my son, Dr. Lonnie Pond, who has joined me in practice. Together, we have found that the ANATOMETER is an accurate and superior method of determining if the patient does or does not require an adjustment; whether real progress is being made with the patient's health problem; if the adjustment is effective and correctly delivered, and if the progress of the case continues as the adjustment "holds". We have also found that the ANATOMETER reduces the number of required X-rays, because it can be depended on to indicate subluxation reduction which previously was ascertainable only by use of the x-ray following the first adjustment. Now we take post x-ray only after the ANATOMETER shows a maximum reduction in the frontal and transverse planes. The reciprocal relationship between the C-1 subluxation and the physical manifestations is so close that a maximum reduction of the physical manifestations as shown by the ANATOMETER is very highly indicative of subluxation correction.

The ANATOMETER procedure appeals to our patients. They associate their health problems and their progress with the procedure. As the patient sees the beneficial changes taking place in his body, he associates the improved measurements with his feeling of improvement, and he knows that the adjustment is helping him. He better understands, too, that his adjustment, given in the neck, is changing the distortions throughout his entire spinal column; that we are in fact using a full-spine technique. This is especially true if a friend or relative is observing the before and after measurements.

Additionally, we have seen the importance of being able with the ANATOMETER to factually determine if the patient requires a shoe lift because of some bone deformity or abnormality, and to accurately determine with the instrument the amount of lift that will balance the patient.

We find in using the ANATOMETER that problem patients who have retained perhaps fifteen to twenty percent of their pain in the lumbo-sacral areas and in sciatic cases are now holding their corrections longer when adjusted to ANATOMETER requirements, and are becoming more rapidly asymptomatic. This fact, to me, is acceptable proof of the chiropractic premise, and



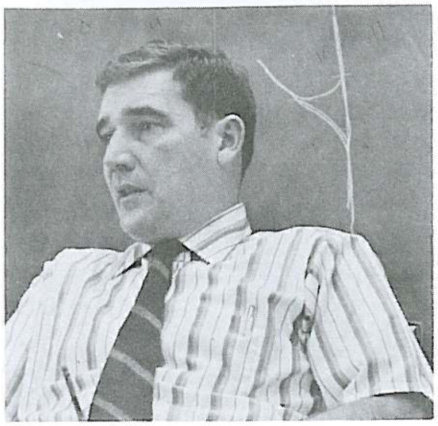
Lloyd C. Pond, D.C.

that maximum reduction of the subluxation is essential to patient response.

Another area of considerable interest and importance to the chiropractic practitioner is the use of the ANATOMETER in detecting potential back injury cases for industry and insurance evaluations. Because the C-1 subluxation is a physical stress-producer, pre-employment examinations with the ANATOMETER may detect evidence of unsuspected weaknesses in spinal musculature and in the spinal column that may well preclude the feasibility of employment at strenuous occupations.

Having used the ANATOMETER in practice, I find its importance to be paramount. It is my further opinion that the importance of, and the need for, this instrument is far greater than we may know at this point. This I know: I would not want to practice without one!

Daniel C. Seemann Elected Executive Director by NUCCA



The new Executive Director of the National Upper Cervical Chiropractic Association, Inc. (NUCCA), Professor Daniel C. Seemann of the University of Toledo, brings to NUCCA a wide experience in organizational work. Professor Seemann has been Director of Student Activities at the University of Toledo since 1967. Prior positions include Assistant Dean of Student Services Community and Technical College (1964-1967), Director of Student Personnel Services (1963-1964), and he has held the rank of Assistant Professor since 1964, being tenured in 1966. Prior to joining the University, he worked in various industrial capacities as a salesman, production scheduler, personnel manager, and administrative assistant.

University Experiences

Professor Seemann's University experiences include the development of a personnel program in the Community and Technical College (1963) which included hiring of staff, establishing a computer registration program, a public relations' program, and the development of several new curriculums, including nursing. He assisted in designing the Scott Park Campus and in educating the neighbors as to the goals and objectives of the College.

As the first full-time Director of Student Activities at the University, Professor Seemann's responsibilities included the student newspaper (which has grown from a four page to a twenty-four page weekly), radio station, student government, Student Union Board, clubs and organizations, IFC advisor, freshmen orientation, Homecoming, Winter and Spring Weekends, I.D. cards, and the Black Student Union. Student government and the Student Union Board and Blockhouse have received national recognition in their respective fields. Clubs and organizations have grown from sixty to one hundred and fifty. Professor Seemann also helped program the new addition to the Student Union (3.5 million).

A member of the Athletic Board of Control since 1966, Professor Seemann served as its chairman in 1972 and 1973. He also served as chairman of the Multipurpose Activities Center Committee whose recommendation was adopted by the Board of Trustees (1973). From 1968 to 1971, he chaired the Central Board of Student Publications.

External Affiliations

Professor Seemann holds the rank of Colonel in the Marine Corps Reserve. He was Evaluation Coordinator for the Vista Training Unit (1966), and Chairman of the Task Force on Mental Disabilities, Region 1, Governor's Council on Vocational Rehabilitation (1968). In 1969, he was appointed a certified trainer of the National Leadership Institute. From 1969-1972, he served as a member of the Board of Trustees of Rescue, Inc. (Suicide prevention). In 1964, he was awarded the Navy Commendation Medal.

Since 1971, Professor Seemann has been Research Consultant to the National Upper Cervical Chiropractic Research Association, Inc. (NUCCRA), a non-profit association incorporated under Michigan Statute for the sole purpose of chiropractic research. Since assuming this position, Professor Seemann has made a thorough study of upper cervical chiropractic, and has contributed considerably to the success of the Corporation's research programs, including the ANATOMETER Project.

Educational Awards

Currently completing the requirements for a Ph. D. in counseling and guidance, Educational Psychology and Research Design and Statistics, Professor Seemann's interests are in small group behavior and leadership as well as in the Atlas Subluxation Complex. He received his masters in psychology (1962) and a bachelors from Columbia College in 1952. He is a member of the Phi Kappa Delta and the Phi Delta Theta Honoraries. In 1970, he was listed in American Universities and Colleges.

Publications

1. "STUDY GUIDE FOR PRINCIPLES OF PSYCHOLOGY" (1961) Co-author) (University of Toledo).
2. "C-1 SUBLUXATIONS AND PELVIC DISTORTIONS" Gregory & Seemann. May, 1975. **International Review of Chiropractic.**
3. "AN ANALYSIS OF COMPLIANCE BEHAVIOR AS IT RELATES TO MEDICINE AND OTHER HEALTH FIELDS" May, 1975. **Upper Cervical Monograph.**
4. "AN ANALYSIS OF SOME HYPOTHESES ABOUT THE ATLAS SUBLUXATION COMPLEX" Gregory and Seemann. Jan., 1976. **The Digest of Chiropractic Economics.**
5. "A STUDY OF DELAYED FEED BACK AND PATIENT-DOCTOR AGREEMENT REINFORCERS AS THEY RELATE TO COMPLIANCE BEHAVIOR" October, 1975. **Upper Cervical Monograph.**
6. "SO YOU WOULD LIKE TO WRITE A RESEARCH ARTICLE" Dec., 1973. **Upper Cervical Monograph.**
7. "NUCCA DIRECTION - QUESTION OF SURVIVAL" March, 1973. **Upper Cervical Monograph.**

Continued on Page Eleven

Continued from Page Two

go to the nearest hospital for X-rays of my neck and back, and he informed me that he would call the following day with his diagnosis. His recommendation was for surgery to be performed in order to fuse several vertebrae that were out of alignment.

During this same week, my husband had a business meeting and during a conversation with one of the members mentioned my problem. His friend advised my husband to contact Dr. Marshall Dickholtz in Chicago for consultation before considering surgery. An appointment was made immediately, and Dr. Dickholtz X-rayed me and gave me my first adjustment. Within a short time, I was able to sleep without continuous discomfort, and as time elapsed, I was able to move my arms freely again without pain. My headaches also left, and I was enjoying health again.

Without realizing it at the time, my adjustment from Dr. Dickholtz was solving an entirely different health problem. For twenty years I had been plagued with skin cancer. Some of the leisons were so deep into the skin I would have to go to the hospital to have them removed, and for a consecutive number of weeks I took radium and/or X-ray treatments when the tests indicated that the leisons were malignant. Since Dr. Dickholtz's adjustment, over three years ago, I have had no new skin cancer and no recurrences as in the past.

I am continuing my regularly scheduled checkups, and I am in better health than I have been for many years.

Dr. Dickholtz is extremely interested in the welfare of his patients, a kind and considerate man and a very dedicated doctor. I am very grateful to him for saving me from unnecessary surgery, pain, and suffering.

S/S Marylin White
RR 1, Box 46
Grayslake, Illinois 60030

Continued from Page Ten

8. "RADAR AIR TRAFFIC CONTROL: AIRCRAFT SEPARATION AND APPROACH SPEEDS" Sept., 1962. (Master's Thesis, University of Toledo)

Seminars

Since 1969, Professor Seemann has given over 30 Leadership and Systems' seminars to such varied groups as correction workers, university and high school students, church elders and deacons, student personnel workers, teachers and principals resident advisors, and camp counselors.

Administrative Experiences

Professor Seemann has held administrative positions continuously since he graduated from Columbia in 1952. He served as an "operations officer" with the 1st Marine Air Wing in Korea, and for the past 14 years as a dean or a director with the University of Toledo. He has had extensive experience with budgeting, building planning, public relations, printing, and communications.

Research Interests

"Along with the study of the Atlas Subluxation Complex", states Professor Seemann, "I am interested in patient compliance, biofeedback, group dynamics and small group behavior."

Commenting on his new assignment as Executive Director of NUCCA, Professor Seemann stated: "I feel that all members of NUCCA should be involved in the growth of NUCCA, especially the Board of Directors. I have always been associated with 'winners', and I feel that NUCCA is of Olympic quality!"

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NUCCA Scholarship Awards

It was announced at the May NUCCA Convention that the NUCCA Directive Board has authorized a scholarship grant-in-aid award of $200.00. This sum will be paid to chiropractic students currently enrolled in a chartered college of chiropractic who submit to the *Monograph* editor an acceptable article pertaining to the upper cervical spine. The announcement was made by Prof. Daniel C. Seemann, NUCCRA Research Advisor.

Submitted articles may deal with any aspect of the Occipital - atlanto - axial area of the cervical spine: Mechanics, neurological manifestations, analyses of cervical subluxations, corrective techniques for cervical subluxations, detrimental effects of the upper cervical subluxations on the human organism, etc.

All entries will be judged by the NUCCA Directive Board and by Professor Seemann. Their judgment will be final. Accepted articles become the property of the National Upper Cervical Chiropractic Association, Inc. Winners will be announced at the 1976 NUCCA Convention.

NUCCA will attempt to return all manuscripts that are accompanied by a self-addressed, stamped envelope. The organization will not be responsible for lost or mislaid material. The writer should retain a carbon copy.

Further information is available by writing:

NUCCA MONOGRAPH EDITOR
221 West Second Street
Monroe, Michigan 48161

How to Adjust the Atlas Subluxation Complex

(Con't from Vol. 1, No. 10)

THE CONVERSION PHASE

As he starts the Conversion or Sixth adjustic Phase, the adjustor's episternal notch is positioned directly over the transverse process of the Patient. (Point A on the schema shown in Vol. 1, No. 4 Monograph)

OBJECTIVES

The primary objective of the Conversion Phase is to align the adjustor's parallel forces to a more vertical plane. Another objective is to return the adjustor's spinal lever to an exact 90 degree angle to the Horizontal Resultant (HR). (Point D on the schema).

In the discussion of the Turn-In Phase (Vol. 1, No. 8), it was pointed out that the objective of the Turn-In Phase is to position the adjustor's episternal notch over the transverse process without losing the conversion of his pelvic and shoulder levers acquired in the Settleback Phase. In the Conversion Phase -- so named because it further converts the adjustor's body to a more vertical plane -- the adjustor must attain more conversion so that his parallel forces are nearly collinear with the mathematically established Notch Transverse Resultant (NTR) (see Vol. 1, No. 3, Page 5) obtained from the patient's X-ray analysis. While in the Turn-In Phase the centers of motion utilized are in the adjustor's ankles, in the Conversion Phase the center of motion is confined to the adjustor's episternal notch.

STEPS

1. The adjustor rotates his spinal lever **as a unit** around his episternal notch. The episternal notch is chosen because it causes faster conversion of the shoulder and pelvic levers to a more vertical plane. (The secret of reducing large rotations and extremely high lines of drive is in the accurate performance of this phase.) Two common errors are: rotating the spinal column around too low a center, and moving too fast with the episternal notch out the Horizontal Resultant.

2. In rotating his spinal lever around his episternal notch, the adjustor moves his trunk along a plane from his outside shoulder to his inside hip, thus forcing the trunk of his body to convert or angle to a more vertical plane.

3. By increasing the hip lock action on the anterior-inferior aspect of his outside hip, the adjustor can shift his greater weight to the outside foot which is an advantage in performing the Pelvic Lever, or succeeding, phase. The adjustor should also maintain a backward pull with his contact hand, wrist, and arm so as to maintain shoulder and arm positions previously established.

4. When fully completed with the Conversion Phase, or when adjustor's spinal column is at a 90 degree angle to the HR at point D, the adjustor checks the relationship of his tie to the HR which, at point D following conversion, should be one inch beyond the HR.

(Con't in Vol. 2, No. 2)